(12) PATENT **(11)** Application No. **AU 200137283 B2**
(19) AUSTRALIAN PATENT OFFICE **(10)** Patent No. **782908**

(54) Title
Phenanthridine-N-oxides

(51)[7] International Patent Classification(s)
C07D 221/12 **A61P 011/06**
A61K 031/473

(21) Application No: **200137283** (22) Application Date: **2001.01.10**

(87) WIPO No: **WO01/51470**

(30) Priority Data

(31) Number	(32) Date	(33) Country
00100482	**2000.01.11**	**EP**

(43) Publication Date : **2001.07.24**
(43) Publication Journal Date : **2001.10.04**
(44) Accepted Journal Date : **2005.09.08**

(71) Applicant(s)
ALTANA Pharma AG

(72) Inventor(s)
Dieter Flockerzi; Gerhard Grundler; Armin Hatzelmann; Daniela Bundschuh; Hans-Peter Kley; Beate Schmidt

(74) Agent/Attorney
Griffith Hack,GPO Box 1285K,MELBOURNE VIC 3001

AU 200137283

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
19 July 2001 (19.07.2001)

PCT

(10) International Publication Number
WO 01/51470 A1

(51) International Patent Classification[7]: C07D 221/12, A61K 31/473, A61P 11/06

(21) International Application Number: PCT/EP01/00223

(22) International Filing Date: 10 January 2001 (10.01.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
00100482.9 11 January 2000 (11.01.2000) EP

(71) Applicant *(for all designated States except US)*: ~~BYK-GULDEN LOMBERG CHEMISCHE FABRIK GMBH~~ ALTANA Pharma AG [DE/DE]; ~~Patentabteilung~~, Byk-Gulden-Strasse 2, 78467 Konstanz (DE).

(72) Inventors *(for all designated States except CA, US)*: **FLOCKERZI, Dieter**; Ackerweg 26, 78476 Allensbach (DE). **GRUNDLER, Gerhard**; Meersburger Str. 4, 78464 Konstanz (DE). **HATZELMANN, Armin**; Alter Wall 3, 78467 Konstanz (DE). **BUNDSCHUH, Daniela**; Rheingutstrasse 17, 78462 Konstanz (DE). **KLEY, Hans-Peter**; Im Weinberg 3b, 78476 Allensbach (DE).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: ~~GUTTERER~~ Schmidt, Beate [DE/DE]; Allensbacher Str. 5, 78476 Allensbach (DE).

(74) Common Representative: **BYK GULDEN LOMBERG CHEMISCHE FABRIK GMBH**; Patentabteilung, Byk-Gulden-Strasse 2, 78467 Konstanz (DE).

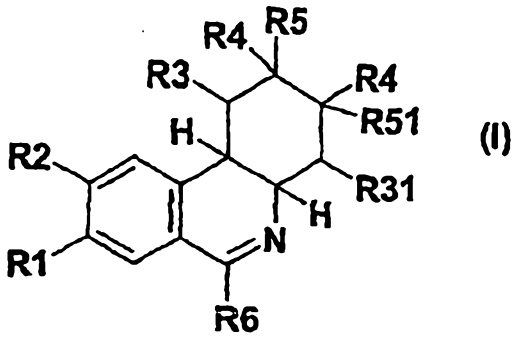
(81) Designated States *(national)*: AE, AL, AU, BA, BG, BR, CA, CN, CZ, EE, GE, HR, HU, ID, IL, IN, JP, KR, LT, LV, MK, MX, NO, NZ, PL, RO, SG, SI, SK, UA, US, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR).

Published:
— *with international search report*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: PHENANTHRIDINE-N-OXIDES



(I)

(57) Abstract: N-oxides of the compounds of formula (I) in which R1 is hydroxyl, 1-4C-alkoxy, 3-7C-cycloalkoxy, 3-7C-cycloalkylmethoxy or completely or predominantly fluorine-substituted 1-4C-alkoxy, R2 is hydroxyl, 1-4C-alkoxy, 3-7C-cycloalkoxy, 3-7C-cycloalkylmethoxy or completely or predominantly fluorine-substituted 1-4C-alkoxy, or in which R1 and R2 together are a 1-2C-alkylenedioxy group, R6 is an R7- and R8-substituted phenyl radical, they are active bronchial therapeutics.

WO 01/51470 A1

Phenanthridine-N-oxides

Field of application of the invention

The invention relates to novel phenanthridine-N-oxides, which are used in the pharmaceutical industry for the production of medicaments.

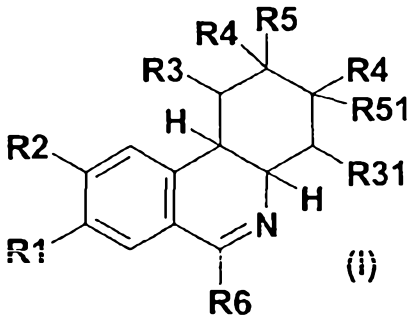
Known technical background

Chem.Ber. **1939**, 72, 675-677, J. Chem. Soc., **1956**, 4280-4283 and J. Chem. Soc.(C), **1971**, 1805 describe the synthesis of 6-phenylphenanthridines. The International Applications WO 97/28131 and WO 97/35854 describe 6-phenyl- and 6-pyridylphenanthridines as PDE4 inhibitors.

Description of the invention

It has now been found that the novel N-oxides of substituted 6-phenylphenanthridines described in greater detail below have surprising and particularly advantageous properties.

The invention thus relates to the N-oxides of the compounds of the formula I,



(I)

in which

R1 is hydroxyl, 1-4C-alkoxy, 3-7C-cycloalkoxy, 3-7C-cycloalkylmethoxy or completely or predominantly fluorine-substituted 1-4C-alkoxy,

R2 is hydroxyl, 1-4C-alkoxy, 3-7C-cycloalkoxy, 3-7C-cycloalkylmethoxy or completely or predominantly fluorine-substituted 1-4C-alkoxy,

or in which

R1 and R2 together are a 1-2C-alkylenedioxy group,

R3 is hydrogen or 1-4C-alkyl,

R31 is hydrogen or 1-4C-alkyl,

or in which

R3 and R31 together are a 1-4C-alkylene group,

R4 is hydrogen or 1-4C-alkyl,

R5 is hydrogen,

R51 is hydrogen,

or in which

R5 and R51 together represent an additional bond,

R6 is an R7- and R8-substituted phenyl radical, where

R7 is hydroxyl, halogen, cyano, 1-4C-alkyl, 1-4C-alkoxy, 1-4C-alkylcarbonyloxy, trifluoromethyl, phenyl, phenyl-1-4C-alkyl, nitro, amino, completely or predominantly fluorine-substituted 1-4C-alkoxy, SO_2-R70 or N(R71)R72, where

R70 is 1-4C-alkyl,

R71 is hydrogen, 1-4C-alkyl, SO_2-R9 or SO_2-R10 and

R72 is 1-4C-alkyl, 1-4C-alkylcarbonyl or SO_2-R10,

R8 is hydrogen, hydroxy, halogen, 1-4C-alkoxy or 1-4C-alkyl

and where

R9 and R10 independently of one another are 1-4C-alkyl, phenyl, phenyl-1-4C-alkyl or phenyl which is substituted by one or more identical or different substituents, where the substituents are selected from the group consisting of nitro, 1-4C-alkyl, halogen, 1-4C-alkylcarbonylamino, 1-4C-alkoxy, completely or predominantly fluorine-substituted 1-4C-alkoxy, cyano, phenyl, naphthyl, trifluoromethyl or 1-4C-alkoxycarbonyl,

and the salts of these N-oxides.

1-4C-Alkyl represents a straight-chain or branched alkyl radical having 1 to 4 carbon atoms. Examples which may be mentioned are the butyl, isobutyl, sec-butyl, tert-butyl, propyl, isopropyl and preferably the ethyl and methyl radicals.

1-4C-Alkoxy represents radicals which, in addition to the oxygen atom, contain a straight-chain or branched alkyl radical having 1 to 4 carbon atoms. Examples which may be mentioned are the butoxy, isobutoxy, sec-butoxy, tert-butoxy, propoxy, isopropoxy and preferably the ethoxy and methoxy radicals.

3-7C-Cycloalkoxy represents cyclopropyloxy, cyclobutyloxy, cyclopentyloxy, cyclohexyloxy and cycloheptyloxy, of which cyclopropyloxy, cyclobutyloxy and cyclopentyloxy are preferred.

3-7C-Cycloalkylmethoxy represents cyclopropylmethoxy, cyclobutylmethoxy, cyclopentylmethoxy, cyclohexylmethoxy and cycloheptylmethoxy, of which cyclopropylmethoxy, cyclobutylmethoxy and cyclopentylmethoxy are preferred.

As completely or predominantly fluorine-substituted 1-4C-alkoxy, for example, the 2,2,3,3,3-pentafluoropropoxy, the perfluoroethoxy, the 1,2,2-trifluoroethoxy, in particular the 1,1,2,2-tetrafluoroethoxy, the 2,2,2-trifluoroethoxy, the trifluoromethoxy and preferably the difluoromethoxy radicals may be mentioned. "Predominantly" in this connection means that more than half of the hydrogen atoms are replaced by fluorine atoms.

1-2C-Alkylenedioxy represents, for example, the methylenedioxy [-O-CH_2-O-] and the ethylenedioxy [-O-CH_2-CH_2-O-] radicals.

If R3 and R31 together have the meaning 1-4C-alkylene, the positions 1 and 4 in the N-oxides of the compounds of the formula I are linked to one another by a 1-4C-alkylene bridge, 1-4C-alkylene representing straight-chain or branched alkylene radicals having 1 to 4 carbon atoms. Examples which may be mentioned are the radicals methylene [-CH_2-], ethylene [-CH_2-CH_2-], trimethylene [-CH_2-CH_2-CH_2-], 1,2-dimethylethylene [-$CH(CH_3)$-$CH(CH_3)$-] and isopropylidene [-$C(CH_3)_2$-].

If R5 and R51 together are an additional bond, then the carbon atoms in positions 2 and 3 in the N-oxides of the compounds of the formula I are linked to one another via a double bond.

Halogen within the meaning of the invention is bromine, chlorine or fluorine.

1-4C-Alkylcarbonyloxy represents a carbonyloxy group to which one of the abovementioned 1-4C-alkyl radicals is bonded. An example which may be mentioned is the acetoxy radical [$CH_3C(O)$-O-].

Phenyl-1-4C-alkyl represents one of the abovementioned 1-4C-alkyl radicals which is substituted by a phenyl radical. Examples which may be mentioned are the benzyl radical and the phenethyl radical.

1-4C-Alkylcarbonyl represents a radical which, in addition to the carbonyl group, contains one of the abovementioned 1-4C-alkyl radicals. An example which may be mentioned is the acetyl radical.

1-4C-Alkylcarbonylamino represents an amino radical which is substituted by one of the abovementioned 1-4C-alkylcarbonyl radicals. An example which may be mentioned is the acetylamino radical [$CH_3C(O)$-NH-].

1-4C-Alkoxycarbonyl represents a carbonyl group to which one of the abovementioned 1-4C-alkoxy radicals is bonded. Examples which may be mentioned are the methoxycarbonyl radical [CH_3O-C(O)-] and the ethoxycarbonyl radical [CH_3CH_2O-C(O)-].

Exemplary R7- and R8-substituted phenyl radicals which may be mentioned are the radicals 4-acetamidophenyl, 3-acetamidophenyl, 4-acetoxyphenyl, 3-aminophenyl, 4-aminophenyl,

2-bromophenyl, 4-bromophenyl, 2-chlorophenyl, 3-chlorophenyl, 4-chlorophenyl, 3-bromophenyl, 2,3-dichlorophenyl, 2,4-dichlorophenyl, 2-chloro-4-nitrophenyl, 4-diethylamino-2-methylphenyl, 4-methoxyphenyl, 3-methoxyphenyl, 2-chloro-5-nitrophenyl, 4-chloro-3-nitrophenyl, 2,6-dichlorophenyl, 3,5-dichlorophenyl, 2,5-dichlorophenyl, 2,6-dibromophenyl, 2-cyanophenyl, 3-cyanophenyl, 4-cyanophenyl, 4-diethylaminophenyl, 4-dimethylaminophenyl, 2-fluorophenyl, 4-fluorophenyl, 3-fluorophenyl, 2,4-difluorophenyl, 2,6-difluorophenyl, 2-chloro-6-fluorophenyl, 2-fluoro-5-nitrophenyl, 2-hydroxyphenyl, 3-hydroxy-phenyl, 3,4-dichlorophenyl, 4-hydroxyphenyl, 4-hydroxy-3-methoxyphenyl, 2-hydroxy-4-methoxyphenyl, 2,4-dihydroxyphenyl, 2-methoxyphenyl, 2,3-dimethoxyphenyl, 3,4-dimethoxyphenyl, 2,4-dimethoxyphenyl, 2-dimethylaminophenyl, 2-methylphenyl, 3-methylphenyl, 4-methylphenyl, 2-chloro-6-methylphenyl, 4-methyl-3-nitrophenyl, 2,4-dimethylphenyl, 2,6-dimethylphenyl, 2,3-dimethylphenyl, 2-nitrophenyl, 3-nitrophenyl, 4-nitrophenyl, 2,4-dinitrophenyl, 3,4-dinitrophenyl, 3,5-dinitrophenyl, 2,6-dinitrophenyl, 4-ethoxyphenyl, 2-trifluoromethylphenyl, 4-trifluoromethylphenyl, 3-trifluoromethylphenyl, 4-(p-nitrophenylsulfonamido)phenyl, 3-(p-toluenesulfonamido)phenyl, 4-(p-toluenesulfonamido)phenyl, 4-(4-ethylphenylsulfonamido)phenyl, 4-bis-(p-toluenesulfonyl)aminophenyl, 4-bis(p-nitrophenylsulfonyl)aminophenyl, 3-(p-nitrophenylsulfonamido)phenyl, (N-acetyl-4-p-toluenesulfonamido)phenyl, 4-(benzylsulfonamido)phenyl, 3-(benzylsulfonamido)phenyl, 4-(methylsulfonamido)phenyl, 3-(methylsulfonamido)phenyl, 4-(N-methylmethylsulfonamido)phenyl, 3-(N-methylmethylsulfonamido)phenyl, 4-(3,4-dichlorophenylsulfonamido)phenyl, 3-(3,4-dichlorophenylsulfonamido)phenyl, 4-(3-nitrophenylsulfonamido)phenyl, 3-(3-nitrophenylsulfonamido)phenyl, 4-(4-bromophenylsulfonamido)phenyl, 3-(4-bromophenylsulfonamido)phenyl, 4-(3-bromophenylsulfonamido)phenyl, 3-(3-bromophenylsulfonamido)phenyl, 4-(3-fluorophenylsulfonamido)phenyl, 3-(3-fluorophenylsulfonamido)phenyl, 4-(4-fluorophenylsulfonamido)phenyl, 3-(4-fluorophenylsulfonamido)phenyl, 4-(4-chlorophenylsulfonamido)phenyl, 3-(4-chlorophenylsulfonamido)phenyl, 4-(3-chlorophenylsulfonamido)phenyl, 3-(3-chlorophenylsulfonamido)phenyl, 4-(4-acetylaminophenylsulfonamido)phenyl, 3-(4-acetylaminophenylsulfonamido)-phenyl, 4-(4-methoxyphenylsulfonamido)phenyl, 3-(4-methoxyphenylsulfonamido)phenyl, 4-(3-trifluoromethylphenylsulfonamido)phenyl, 3-(3-trifluoromethylphenylsulfonamido)phenyl, 4-(4-trifluoromethylphenylsulfonamido)phenyl, 3-(4-trifluoromethylphenylsulfonamido)phenyl, 4-(4-trifluoromethoxyphenylsulfonamido)phenyl, 3-(4-trifluoromethoxyphenylsulfonamido)phenyl, 4-(3-methylphenylsulfonamido)-phenyl, 3-(3-methylphenylsulfonamido)phenyl, 4-(3,4-dimethoxyphenylsulfonamido)phenyl, 3-(3,4-dimethoxyphenylsulfonamido)phenyl, 4-(4-cyanophenylsulfonamido)phenyl, 3-(4-cyanophenylsulfonamido)phenyl, 4-(3-cyanophenylsulfonamido)phenyl, 3-(3-cyanophenylsulfonamido)phenyl, 4-(3-chloro-4-methylphenylsulfonamido)phenyl, 3-(3-chloro-4-methylphenylsulfonamido)phenyl, 4-(4-biphenylsulfonamido)phenyl, 3-(4-biphenylsulfonamido)phenyl, 4-(4-isopropylphenylsulfonamido)phenyl, 3-(4-isopropylphenylsulfonamido)phenyl, 4-(naphth-1-ylsulfonamido)phenyl, 3-(naphth-1-ylsulfonamido)phenyl, 4-(naphth-2-ylsulfonamido)phenyl, 3-(naphth-2-ylsulfonamido)phenyl, 4-benzylphenyl, 4-biphenyl, 4-trifluoromethoxyphenyl, 3-trifluoromethoxyphenyl, 2-trifluoromethoxyphenyl, 4-methanesulfonylphenyl, 3-methanesulfonylphenyl, 2-methane-

sulfonylphenyl, 4-(4-methoxycarbonylphenylsulfonamido)phenyl or (N-methyl-4-p-toluenesulfonamido)phenyl.

Possible salts for the N-oxides of the compounds of the formula I - depending on substitution - are all acid addition salts or all salts with bases. Particular mention may be made of the pharmacologically tolerable salts of the inorganic and organic acids and bases customarily used in pharmacy. Those suitable are, on the one hand, water-soluble and water-insoluble acid addition salts with acids such as, for example, hydrochloric acid, hydrobromic acid, phosphoric acid, nitric acid, sulfuric acid, acetic acid, citric acid, D-gluconic acid, benzoic acid, 2-(4-hydroxybenzoyl)benzoic acid, butyric acid, sulfosalicylic acid, maleic acid, lauric acid, malic acid, fumaric acid, succinic acid, oxalic acid, tartaric acid, embonic acid, stearic acid, toluenesulfonic acid, methanesulfonic acid or 3-hydroxy-2-naphthoic acid, it being possible to employ the acids in salt preparation - depending on whether a mono- or polybasic acid is concerned and depending on which salt is desired - in an equimolar quantitative ratio or one differing therefrom.

On the other hand, salts with bases are also suitable. Examples of salts with bases which may be mentioned are alkali metal (lithium, sodium, potassium) or calcium, aluminum, magnesium, titanium, ammonium, meglumine or guanidinium salts, where here too the bases are employed in salt preparation in an equimolar quantitative ratio or one differing therefrom.

Pharmacologically intolerable salts which can initially be obtained, for example, as process products in the preparation of the compounds according to the invention on an industrial scale are converted into pharmacologically tolerable salts by processes known to the person skilled in the art.

It is known to the person skilled in the art that the N-oxides according to the invention and their salts, when they are isolated, for example, in crystalline form, can contain various amounts of solvents. The invention therefore also comprises all solvates and in particular all hydrates of the N-oxides according to the invention, and also all solvates and in particular all hydrates of the salts of the N-oxides according to the invention.

The N-oxides of the compounds of the formula I to be emphasized are those in which

R1 is 1-2C-alkoxy, 3-5C-cycloalkoxy, 3-5C-cycloalkylmethoxy or completely or predominantly fluorine-substituted 1-2C-alkoxy,

R2 is 1-2C-alkoxy, 3-5C-cycloalkoxy, 3-5C-cycloalkylmethoxy or completely or predominantly fluorine-substituted 1-2C-alkoxy,

R3 is hydrogen,

R31 is hydrogen,

R4 is hydrogen or 1-2C-alkyl,

R5 is hydrogen,

R51 is hydrogen,

or in which

R5 and R51 together represent an additional bond,

R6 is an R7- and R8-substituted phenyl radical, where

R7 is hydroxyl, halogen, cyano, 1-4C-alkoxy, 1-4C-alkylcarbonyloxy, trifluoromethyl, phenyl, phenyl-1-4C-alkyl, nitro, amino, completely or predominantly fluorine-substituted 1-4C-alkoxy, SO_2-R70 or N(R71)R72, where

R70 is 1-4C-alkyl,

R71 is hydrogen, 1-4C-alkyl, SO_2-R9 or SO_2-R10 and

R72 is 1-4C-alkyl, 1-4C-alkylcarbonyl or SO_2-R10,

R8 is hydrogen, halogen or 1-4C-alkoxy

and where

R9 and R10 independently of one another are 1-4C-alkyl, phenyl or phenyl substituted by a substituent, where the substituent is selected from the group consisting of nitro, 1-4C-alkyl, 1-4C-alkoxy, halogen, trifluoromethyl or 1-4C-alkoxycarbonyl,

and the salts of these N-oxides.

The N-oxides of the compounds of the formula I particularly to be emphasized are those in which

R1 is 1-2C-alkoxy,

R2 is 1-2C-alkoxy,

R3, R31, R4, R5 and R51 are hydrogen,

R6 is an R7- and R8-substituted phenyl radical, where

R7 is hydroxyl, halogen, 1-4C-alkoxy, 1-4C-alkylcarbonyloxy, phenyl, phenyl-1-4C-alkyl, nitro, amino, SO_2-R70 or N(R71)R72, where

R70 is 1-4C-alkyl,

R71 is hydrogen or SO_2-R10 and

R72 is 1-4C-alkyl, 1-4C-alkylcarbonyl or SO_2-R10,

R8 is hydrogen, halogen or 1-4C-alkoxy

and where

R10 is phenyl substituted by a substituent, where the substituent is selected from the group consisting of nitro, 1-4C-alkyl or 1-4C-alkoxycarbonyl,

and the salts of these N-oxides.

Preferred N-oxides of the compounds of the formula I are those in which

R1 is 1-2C-alkoxy,

R2 is 1-2C-alkoxy,

R3, R31, R4, R5 and R51 are hydrogen,

R6 is an R7- and R8-substituted phenyl radical, where

R7 is SO_2-R70,

R70 is 1-4C-alkyl,

R8 is hydrogen.

and the salts of these N-oxides.

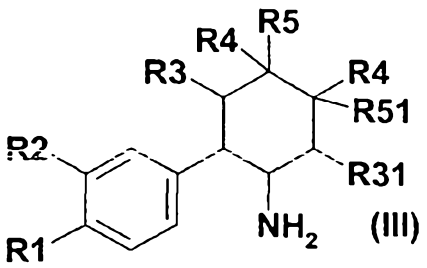
The N-oxides of the compounds of the formula I are chiral compounds having chiral centers in positions 4a and 10b and, depending on the meaning of the substituents R3, R31, R4, R5 and R51, further chiral centers in the positions 1, 2, 3 and 4.

The invention therefore comprises all conceivable pure diastereomers and pure enantiomers and their mixtures in any mixing ratio, including the racemates. The N-oxides of the compounds of the formula I are preferred in which the hydrogen atoms in positions 4a and 10b are cis to one another. The pure cis enantiomers are particularly preferred here.

Particularly preferred in this connection are those N-oxides of the compounds of the formula I which in the positions 4a and 10b have the same absolute configuration as the compound (-)-cis-1,2-dimethoxy-4-(2-aminocyclohexyl)benzene which on its part can be employed as a starting material having the optical rotation $[\alpha]_D^{20} = -58.5°$ (c = 1, ethanol).

The enantiomers can be separated in a manner known per se (for example by preparation and separation of appropriate diastereoisomeric compounds).

Preferably, an enantiomer separation is carried out at the stage of the starting compounds of the formula III

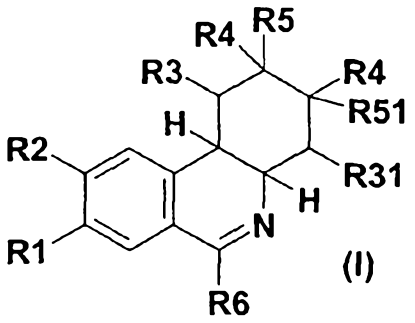


(III)

for example by means of salt formation of the racemic compounds of the formula III with optically active carboxylic acids. Examples which may be mentioned in this connection are the enantiomeric forms of mandelic acid, tartaric acid, O,O'-dibenzoyltartaric acid, camphoric acid, quinic acid, glutamic acid, malic acid, camphorsulfonic acid, 3-bromocamphorsulfonic acid, α-methoxyphenylacetic acid, α-methoxy-α-trifluoromethylphenylacetic acid and 2-phenylpropionic acid. Alternatively, enantiomerically pure starting compounds of the formula III can also be prepared via asymmetric syntheses.

The N-oxides of the compounds of the formula I can be prepared, for example, by the process described below in greater detail.

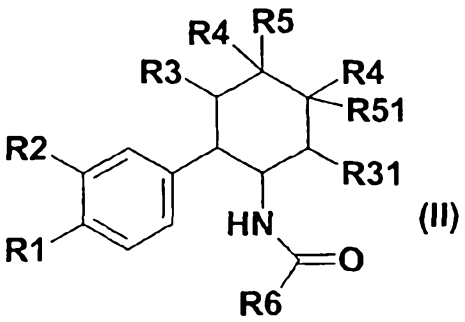
The process comprises subjecting compounds of the formula I,



in which R1, R2, R3, R31, R4, R5, R51 and R6 have the meanings indicated above, to an N-oxidation and, if desired, then converting the N-oxides of the compounds of the formula I obtained into their salts, or, if desired, then converting salts of the N-oxides of the compounds of the formula I obtained into the free compounds.

The N-oxidation is carried out in a manner familiar to the person skilled in the art, e.g. with the aid of hydrogen peroxide in methanol or with the aid of m-chloroperoxybenzoic acid in dichloromethane at room temperature. The person skilled in the art will be familiar on the basis of his/her expert knowledge with the reaction conditions which are specifically necessary for carrying out the N-oxidation.

Compounds of the formula I, in which R1, R2, R3, R31, R4, R5, R51 and R6 have the meanings indicated above, can be prepared from the corresponding compounds of the formula II by a cyclocondensation reaction.



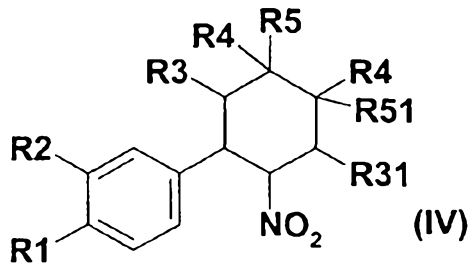
The cyclocondensation is carried out in a manner known per se to the person skilled in the art, according to Bischler-Napieralski (e.g. as described in J. Chem. Soc., 1956, 4280-4282) in the presence of a

suitable condensing agent, such as, for example, polyphosphoric acid, phosphorus pentachloride, phosphorus pentoxide or preferably phosphorus oxychloride, in a suitable inert solvent, e.g. in a chlorinated hydrocarbon such as chloroform, or in a cyclic hydrocarbon such as toluene or xylene, or another inert solvent such as acetonitrile, or without further solvent using an excess of condensing agent, preferably at elevated temperature, in particular at the boiling temperature of the solvent or condensing agent used.

Compounds of the formula II in which R1, R2, R3, R31, R4, R5, R51 and R6 have the meanings indicated above are accessible from the corresponding compounds of the formula III, in which R1, R2, R3, R31, R4, R5 and R51 have the meanings indicated above, by reaction with compounds of the formula R6-CO-X, in which R6 has the meanings indicated above and X represents a suitable leaving group, preferably a chlorine atom. For example, the acylation or benzoylation is carried out as described in the following examples or as in J. Chem. Soc. (C), **1971**, 1805-1808.

Compounds of the formula R6-CO-X and compounds of the formula III are either known or can be prepared in a known manner.

The compounds of the formula III can be prepared, for example, from compounds of the formula IV,



(IV)

in which R1, R2, R3, R31, R4, R5 and R51 have the abovementioned meanings, by reduction of the nitro group.

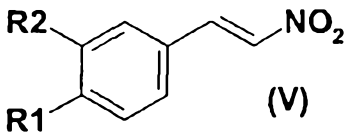
The reduction is carried out in a manner known to the person skilled in the art, for example as described in J. Org. Chem. **1962**, 27, 4426 or as described in the following examples.

The reduction can be carried out, for example, by catalytic hydrogenation, e.g. in the presence of Raney nickel, in a lower alcohol such as methanol or ethanol at room temperature and under normal or elevated pressure. If desired, a catalytic amount of an acid, such as, for example, hydrochloric acid, can be added to the solvent. Preferably, however, the reduction is carried out using metals such as zinc or iron with organic acids such as acetic acid or mineral acids such as hydrochloric acid.

The compounds of the formula III in which R1, R2, R3, R31 and R4 have the meanings indicated above and R5 and R51 together represent an additional bond can be prepared from the corresponding compounds of the formula IV by selective reduction of the nitro group in a manner known to the person skilled in the art, for example in the presence of Raney nickel in a lower alcohol as solvent using hydrazine hydrate as a hydrogen donor.

The compounds of the formula IV, in which R1, R2, R3, R31 and R4 have the meanings indicated above and R5 and R51 are hydrogen, are either known or can be prepared from corresponding compounds of the formula IV in which R5 and R51 together are an additional bond. The reaction can be carried out in a manner known to the person skilled in the art, preferably by hydrogenation in the presence of a catalyst, such as, for example, palladium on active carbon, e.g. as described in J. Chem. Soc. (C), **1971**, 1805-1808.

The compounds of the formula IV, in which R5 and R51 together are an additional bond, are either known or can be obtained by the reaction of compounds of the formula V,



(V)

in which R1 and R2 have the meanings mentioned above, with compounds of the formula VI,

R3-CH=C(R4)-C(R4)=CH-R31 (VI)

in which R3, R31 and R4 have the meanings mentioned above.

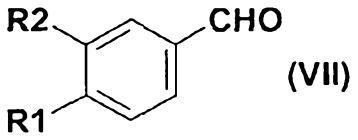
Compounds of the formula IV in which R5 and R51 together are an additional bond and R3 and R31 together are a 1-4C-alkylene group can be obtained, for example, by reaction of cyclic compounds of the formula VI, in which R4 has the meanings indicated above and R3 and R31 together are a 1-4C-alkylene group [e.g. cyclohexa-1,3-diene, 2,3-dimethylcyclohexa-1,3-diene, cyclohepta-1,3-diene, 2,3-dimethylcyclohepta-1,3-diene or cycloocta-1,3-diene], with compounds of the formula V in which R1 and R2 have the meanings indicated above.

The cycloaddition is in this case carried out in a manner known to the person skilled in the art according to Diels-Alder, e.g. as described in J. Amer. Chem. Soc. **1957**, 79, 6559 or in J. Org. Chem. **1952**, 17, 581 or as described in the following examples.

Compounds of the formula IV obtained in the cycloaddition, in which the phenyl ring and the nitro group are trans to one another, can be converted in a manner known to the person skilled in the art into the corresponding cis compounds, e.g. as described in J. Amer. Chem. Soc. **1957**, 79, 6559 or as described in the following examples.

The compounds of the formulae V and VI are either known or can be prepared in a known manner. The compounds of the formula V can be prepared, for example, in a manner known to the person skilled in the art from corresponding compounds of the formula VII as described, for example, in J. Chem. Soc. **1951**, 2524 or in J. Org. Chem. **1944**, 9, 170 or as described in the following examples.

The compounds of the formula VII,



(VII)

in which R1 and R2 have the meanings indicated above, are either known or can be prepared in a manner known to the person skilled in the art, as described, for example, in Ber. Dtsch. Chem. Ges. **1925**, 58, 203.

It is moreover known to the person skilled in the art that if there are a number of reactive centers on a starting or intermediate compound it may be necessary to block one or more reactive centers temporarily by protective groups in order to allow a reaction to proceed specifically at the desired reaction center. A detailed description for the use of a large number of proven protective groups is found, for example, in T.W. Greene, Protective Groups in Organic Synthesis, John Wiley & Sons, 1991.

The isolation and purification of the substances according to the invention is carried out in a manner known per se, e.g. by distilling off the solvent in vacuo and recrystallizing the resulting residue from a suitable solvent or subjecting it to one of the customary purification methods, such as, for example, column chromatography on suitable support material.

Salts are obtained by dissolving the free compound in a suitable solvent (e.g. a ketone, such as acetone, methyl ethyl ketone or methyl isobutyl ketone, an ether, such as diethyl ether, tetradhydrofuran or dioxane, a chlorinated hydrocarbon, such as methylene chloride or chloroform, or a low molecular weight aliphatic alcohol such as ethanol or isopropanol) which contains the desired acid or base, or to which the desired acid or base is then added. The salts are obtained by filtering, reprecipitating, precipitating with a nonsolvent for the addition salt or by evaporating the solvent. Salts obtained can be converted by alkalization or by acidification into the free compounds, which in turn can be converted

into salts. In this way, pharmacologically intolerable salts can be converted into pharmacologically tolerable salts.

The following examples serve to illustrate the invention further without restricting it. Likewise, further compounds of the formula I, whose preparation is not explicitly described, can be prepared in an analogous manner or in a manner familiar per se to the person skilled in the art using customary process techniques.

In the examples, m.p stands for melting point, h for hour(s), RT for room temperature, EF for empirical formula, MW for molecular weight, calc. for calculated, fnd. for found. The N-oxide mentioned as example is a preferred subject of the invention.

Examples

Final products

1. (-)-cis-8,9-Dimethoxy-6-(4-methanesulfonylphenyl)-1,2,3,4,4a,10b-hexahydrophenanthridine-N-oxide

500 mg of (-)-cis-8,9-dimethoxy-6-(4-methanesulfonylphenyl)-1,2,3,4,4a,10b-hexahydrophenanthridine are dissolved in 30 ml of dichloromethane, treated with 340 mg of m-chloroperbenzoic acid with ice-cooling and stirred in an ice bath for 3 h and at RT for 1 h. After removing the solvent under reduced pressure and chromatography on silica gel using ethyl acetate/triethylamine in the ratio 7:1, the title compound is obtained by concentrating the product fractions.

EF: $C_{22}H_{25}NO_5S$ MW: 415.51
M.p.: 229-231 °C
Elemental analysis:
calc.: C 63.60 H 6.06 N 3.35 S 7.72
found: C 63.34 H 6.03 N 3.30 S 7.98
Optical rotation: $[\alpha]_D^{20}$ = -27.3° (c=0.2, ethanol)

Starting compounds

A1. (-)-cis-8,9-Dimethoxy-6-(4-methanesulfonylphenyl)-1,2,3,4,4a,10b-hexahydrophenanthridine

8.0 g of (-)-cis-N-[2-(3,4-dimethoxyphenyl)cyclohexyl]-4-methanesulfonylbenzamide are suspended in 150 ml of toluene, treated with 4 ml of phosphorus oxychloride and heated under reflux for 5.5 h. The reaction solution is concentrated under reduced pressure, the residue is taken up in ethyl acetate and the mixture is extracted with satd sodium hydrogencarbonate solution and water. After chromatography on silica gel using petroleum ether/ethyl acetate/triethylamine in the ratio 6/3/1, the title compound is obtained.

EF: $C_{22}H_{25}NO_4S$ MW: 399.51
M.p.: 170-172.5 °C
Elemental analysis:
calc.: C 66.14 H 6.31 N 3.51 S 8.02
found: C 66.00 H 6.31 N 3.35 S 7.77

Optical rotation: $[\alpha]_D^{20}$ = -10.2° (c=0.2, ethanol)

B1. (-)-cis-N-[2-(3,4-Dimethoxyphenyl)cyclohexyl]-4-methanesulfonylbenzamide

5.0 g of (-)-cis-1,2-dimethoxy-4-(2-aminocyclohexyl)benzene are dissolved in 40 ml of dichloromethane and treated with 5.0 ml of triethylamine and a solution of 6.6 g of 4-methanesulfonylbenzoyl chloride in 30 ml of dichloromethane with ice-cooling. After stirring overnight at RT, the mixture is extracted with 2N hydrochloric acid solution, satd sodium hydrogencarbonate solution and water. The organic phase is dried using sodium sulfate and concentrated under reduced pressure. The residue is recrystallized from ethyl acetate.

EF: $C_{22}H_{27}NO_5S$ MW: 417.53
M.p.: 159-162°C
Optical rotation: $[\alpha]_D^{20}$ = -146.2° (c=0.2, ethanol)

C1. (+/-)-cis-1,2-Dimethoxy-4-(2-aminocyclohexyl)benzene

125 g of (+/-)-cis-1,2-dimethoxy-4-(2-nitrocyclohexyl)benzene and 120 g of zinc powder or granules are suspended in 1300 ml of ethanol. 220 ml of acetic acid are added dropwise at boiling heat. The precipitate is filtered off with suction and washed with ethanol, and the filtrate is concentrated under reduced pressure. The residue is taken up in hydrochloric acid and extracted with toluene. The aqueous phase is rendered alkaline using 50% strength sodium hydroxide solution, the precipitate is filtered off with suction and the filtrate is extracted with toluene. The organic phase is dried using sodium sulfate and concentrated. 98 g of the title compound are obtained as a crystallizing oil.

Alternatively:

8.5 g of (+/-)-cis-1,2-dimethoxy-4-(2-nitrocyclohexyl)benzene are dissolved in 400 ml of methanol and treated at RT with 7 ml of hydrazine hydrate and 2.5 g of Raney nickel in portions in the course of 8 h. After stirring overnight at RT, the reaction mixture is filtered, the filtrate is concentrated and the residue is chromatographed on silica gel using a mixture of toluene/ethyl acetate/triethylamine = 4/2/0.5. The title compound is obtained as an oil.

C2. (-)-cis-1,2-Dimethoxy-4-(2-aminocyclohexyl)benzene

12.0 g of (+/-)-cis-1,2-dimethoxy-4-(2-aminocyclohexyl)benzene and 6.2 g of (-)-mandelic acid are dissolved in 420 ml of dioxane and 60 ml of tetrahydrofuran and the solution is stirred overnight at RT. The solid is filtered off with suction, dried, treated with 100 ml of saturated sodium hydrogencarbonate solu-

tion and extracted with ethyl acetate. The organic phase is dried using sodium sulphate and concentrated under reduced pressure. 4.8 g of the title compound are obtained of m.p.: 80-81.5°C.
Specific rotation: $[\alpha]_D^{20}$ = -58.5°C (c = 1, ethanol).

D1. (+/-)-cis-1,2-Dimethoxy-4-(2-nitrocyclohexyl)benzene

8.4 g of (+/-)-cis-1,2-dimethoxy-4-(2-nitrocyclohex-4-enyl)benzene are dissolved in 450 ml of methanol, treated with 2 ml of conc. hydrochloric acid and hydrogenated after addition of 500 mg of 10% strength Pd/C. The reaction mixture is filtered and the filtrate is concentrated. M.p.: 84-86.5°C.

D2. (+/-)-cis-1,2-Dimethoxy-4-(2-nitrocyclohex-4-enyl)benzene

10.0 g of (+/-)-trans-1,2-dimethoxy-4-(2-nitrocyclohex-4-enyl)benzene and 20.0 g of potassium hydroxide are dissolved in 150 ml of ethanol and 35 ml of dimethylformamide. A solution of 17.5 ml of conc. sulfuric acid in 60 ml of ethanol is then added dropwise such that the internal temperature does not exceed 4°C. After stirring for 1 h, the mixture is added to 1 l of ice water, the precipitate is filtered off with suction, washed with water and dried, and the crude product is recrystallized from ethanol. 8.6 g of the title compound of m.p. 82.5-84°C are obtained.

D3. (+/-)-trans-1,2-Dimethoxy-4-(2-nitrocyclohex-4-enyl)benzene

50.0 g of 3,4-dimethoxy-ω-nitrostyrene and 1.0 g (9.1 mmol) of hydroquinone are suspended in 200 ml of abs. toluene and treated at -70°C with 55.0 g (1.02 mol) of liquid 1,3-butadiene. The mixture is stirred at 160°C for 6 days in an autoclave and then cooled. Some of the solvent is removed on a rotary evaporator, and the resulting precipitate is filtered off with suction and recrystallized in ethanol. M.p.: 113.5-115.5°C.

E1. 3,4-Dimethoxy-ω-nitrostyrene

207.0 g of 3,4-dimethoxybenzaldehyde, 100.0 g of ammonium acetate and 125 ml of nitromethane are heated to boiling for 3-4 h in 1.0 l of glacial acetic acid. After cooling in an ice bath, the precipitate is filtered off with suction, rinsed with glacial acetic acid and petroleum ether and dried. M.p.: 140-141°C. Yield: 179.0 g.

Commercial applicability

The N-oxides according to the invention have valuable pharmacological properties which make them commercially utilizable. As selective cyclic nucleotide phosphodiesterase (PDE) inhibitors (namely of type 4), they are suitable on the one hand as bronchial therapeutics (for the treatment of airway obstructions on account of their dilating but also on account of their respiratory rate- or respiratory drive-increasing action) and for the elimination of erectile dysfunction on account of the vasodilating action, but on the other hand especially for the treatment of disorders, in particular of inflammatory nature, e.g. of the airways (asthma prophylaxis), of the skin, of the central nervous system, of the intestine, of the eyes and of the joints, which are mediated by mediators such as histamine, PAF (platelet-activating factor), arachidonic acid derivatives such as leukotrienes and prostaglandins, cytokines, interleukins, chemokines, alpha-, beta- and gamma-interferon, tumor necrosis factor (TNF) or oxygen radicals and proteases. The N-oxides according to the invention are distinguished here by low toxicity, good enteral absorption (high bioavailability), a large therapeutic breadth and the absence of significant side-effects.

On account of their PDE-inhibiting properties, the N-oxides according to the invention can be employed in human and veterinary medicine and therapeutics, where they can be used, for example, for the treatment and prophylaxis of the following illnesses: acute and chronic (in particular inflammatory and allergen-induced) airway disorders of various origins (bronchitis, allergic bronchitis, bronchial asthma, emphysema, COPD); dermatoses (especially of proliferative, inflammatory and allergic type) such as, for example, psoriasis (vulgaris), toxic and allergic contact eczema, atopic eczema, seborrheic eczema, lichen simplex, sunburn, pruritus in the anogenital area, alopecia areata, hypertrophic scars, discoid lupus erythematosus, follicular and wide-area pyodermias, endogenous and exogenous acne, acne rosacea and other proliferative, inflammatory and allergic skin disorders; disorders which are based on an excessive release of TNF and leukotrienes, e.g. disorders of the arthritis type (rheumatoid arthritis, rheumatoid spondylitis, osteoarthritis and other arthritic conditions), disorders of the immune system (AIDS, multiple sclerosis), graft-versus-host reactions, transplant rejection reactions, symptoms of shock [septic shock, endotoxin shock, gram-negative sepsis, toxic shock syndrome and ARDS (adult respiratory distress syndrome)], and generalized inflammations in the gastrointestinal area (Crohn's disease and ulcerative colitis); disorders which are based on allergic and/or chronic, faulty immunological reactions in the area of the upper airways (pharynx, nose) and the adjacent regions (paranasal sinuses, eyes), such as, for example, allergic rhinitis/sinusitis, chronic rhinitis/sinusitis, allergic conjunctivitis and nasal polyps; but also disorders of the heart which can be treated by PDE inhibitors, such as, for example, cardiac insufficiency, or disorders which can be treated on account of the tissue-relaxant action of the PDE inhibitors, such as, for example, erectile dysfunction or colics of the kidneys and the ureters in connection with kidney stones. In addition, the N-oxides according to the invention can be employed for the treatment of diabetes insipidus and disorders in connection with disturbances of brain metabolism, such as, for example, cerebral senility, senile dementia (Alzheimer's dementia), multiin-

farct dementia or alternatively disorders of the CNS, such as, for example, depressions or arteriosclerotic dementia.

A further subject of the invention is a process for the treatment of mammals, including man, which are suffering from one of the abovementioned illnesses. The process comprises administering to the sick mammal a therapeutically efficacious and pharmacologically tolerable amount of one or more of the N-oxides according to the invention.

The invention further relates to the N-oxides according to the invention for use in the treatment and/or prophylaxis of illnesses, in particular the illnesses mentioned.

The invention likewise relates to the use of the N-oxides according to the invention for the production of medicaments which are employed for the treatment and/or prophylaxis of the illnesses mentioned.

Medicaments for the treatment and/or prophylaxis of the illnesses mentioned, which contain one or more of the N-oxides according to the invention, are furthermore a subject of the invention.

A further subject of the invention is a commercial product, consisting of a customary secondary pack, a primary pack containing the medicament (for example an ampoule or a blister pack) and, if desired, a pack insert, the medicament exhibiting antagonistic action against cyclic nucleotide phosphodiesterases of type 4 (PDE4) and leading to the attenuation of the symptoms of illnesses which are connected with cyclic nucleotide phosphodiesterases of type 4, and the suitability of the medicament for the prophylaxis or treatment of illnesses which are connected with cyclic nucleotide phosphodiesterases of type 4 being indicated on the secondary pack and/or on the pack insert of the commercial product, and the medicament containing one or more N-oxides of the compounds of the formula I according to the invention. The secondary pack, the primary pack containing the medicament and the pack insert otherwise comply with what would be regarded as standard to the person skilled in the art for medicaments of this type.

The medicaments are prepared by processes which are known per se and familiar to the person skilled in the art. As medicaments, the N-oxides according to the invention (= active compounds) are either employed as such, or preferably in combination with suitable pharmaceutical excipients, e.g. in the form of tablets, coated tablets, capsules, suppositories, patches, emulsions, suspensions, gels or solutions, the active compound content advantageously being between 0.1 and 95%.

The person skilled in the art is familiar on the basis of his/her expert knowledge with the excipients which are suitable for the desired pharmaceutical formulations. In addition to solvents, gel-forming agents, ointment bases and other active compound vehicles, it is possible to use, for example, antioxidants, dispersants, emulsifiers, preservatives, solubilizers or permeation promoters.

For the treatment of disorders of the respiratory tract, the N-oxides according to the invention are preferably also administered by inhalation in the form of an aerosol; the aerosol particles of solid, liquid or mixed composition preferably having a diameter of 0.5 to 10 µm, advantagously of 2 to 6 µm.

Aerosol generation can be carried out, for example, by pressure-driven jet atomizers or ultrasonic atomizers, but advantageously by propellant-driven metered aerosols or propellant-free administration of micronized active compounds from inhalation capsules.

Depending on the inhaler system used, in addition to the active compounds the administration forms additionally contain the required excipients, such as, for example, propellants (e.g. Frigen in the case of metered aerosols), surface-active substances, emulsifiers, stabilizers, preservatives, flavorings, fillers (e.g. lactose in the case of powder inhalers) or, if appropriate, further active compounds.

For the purposes of inhalation, a large number of apparatuses are available with which aerosols of optimum particle size can be generated and administered, using an inhalation technique which is as right as possible for the patient. In addition to the use of adaptors (spacers, expanders) and pear-shaped containers (e.g. Nebulator®, Volumatic®), and automatic devices emitting a puffer spray (Autohaler®), for metered aerosols, in particular in the case of powder inhalers, a number of technical solutions are available (e.g. Diskhaler®, Rotadisk®, Turbohaler® or the inhaler described in European Patent Application EP 0 505 321), using which an optimal administration of active compound can be achieved.

For the treatment of dermatoses, the N-oxides according to the invention are in particular used in the form of those medicaments which are suitable for topical application. For the production of the medicaments, the N-oxides according to the invention (= active compounds) are preferably mixed with suitable pharmaceutical excipients and further processed to give suitable pharmaceutical formulations. Suitable pharmaceutical formulations which may be mentioned are, for exampie, powders, emulsions, suspensions, sprays, oils, ointments, fatty ointments, creams, pastes, gels or solutions.

The medicaments according to the invention are prepared by processes known per se. Dosage of the active compounds takes place in the order of magnitude customary for PDE inhibitors. Thus topical application forms (such as, for example, ointments) for the treatment of dermatoses contain the active compounds in a concentration of, for example, 0.1-99%. The dose for administration by inhalation is customarily between 0.1 and 3 mg per day. The customary dose in the case of systemic therapy (p.o. or i.v.) is between 0.03 and 3 mg per kilogram per day.

Biological investigations

In the investigation of PDE4 inhibition at the cellular level, the activation of inflammatory cells has particular importance. As an example, the FMLP (N-formyl-methionyl-leucyl-phenylalanine)-induced superoxide production of neutrophilic granulocytes may be mentioned, which can be measured as luminol-potentiated chemoluminescence [McPhail LC, Strum SL, Leone PA and Sozzani S, The neutrophil respiratory burst mechanism. In "Immunology Series" **1992**, 57, 47-76; ed. Coffey RG (Marcel Decker, Inc. New York-Basle-Hong Kong)].

Substances which inhibit chemoluminescence and cytokine secretion and the secretion of inflammatory mediators on inflammatory cells, in particular neutrophilic and eosinophilic granulocytes, T lymphocytes, monocytes and macrophages, are those which inhibit PDE4. This isoenzyme of the phosphodiesterase families is particularly represented in granulocytes. Its inhibition leads to an increase in the intracellular cyclic AMP concentration and thus to the inhibition of cell activation. PDE4 inhibition by the substances according to the invention is thus a central indicator of the suppression of inflammatory processes (**Giembycz MA**, Could isoenzyme-selective phosphodiesterase inhibitors render bronchodilatory therapy redundant in the treatment of bronchial asthma?. Biochem Pharmacol **1992**, 43, 2041-2051; **Torphy TJ** et al., Phosphodiesterase inhibitors: new opportunities for treatment of asthma. Thorax **1991**, 46, 512-523; **Schudt C** et al., Zardaverine: a cyclic AMP PDE 3/4 inhibitor. In "New Drugs for Asthma Therapy", 379-402, Birkhäuser Verlag Basle 1991; **Schudt C** et al., Influence of selective phosphodiesterase inhibitors on human neutrophil functions and levels of cAMP and Ca; Naunyn-Schmiedebergs Arch Pharmacol **1991**, 344, 682-690; **Tenor H** and **Schudt C**, Analysis of PDE isoenzyme profiles in cells and tissues by pharmacological methods. In "Phosphodiesterase Inhibitors", 21-40, "The Handbook of Immunopharmacology", Academic Press, 1996; **Hatzelmann A** et al., Enzymatic and functional aspects of dual-selective PDE3/4-inhibitors. *In* "Phosphodiesterase Inhibitors", 147-160. "The Handbook of Immunopharmacology", Academic Press, 1996).

Inhibition of PDE4 activity

Methodology

The activity test can be carried out, for example, according to the method of Bauer and Schwabe. For this, the method is adapted to microtiter plates (Naunyn-Schmiedeberg's Arch. Pharmacol. 1980, 311, 193-198). The PDE reaction takes place in the first step here. In a second step, the resulting 5'-nucleotide is cleaved by a 5'-nucloetidase of the snake venom of Crotalus atrox to the uncharged nucleoside. In the third step, the nucleoside is separated from the remaining charged substrate on ion-exchange columns. The columns are eluted directly into minivials, into which 2 ml of scintillator fluid are additionally added for counting, using 2 ml of 30 mM ammonium formate (pH 6.0).

Table A

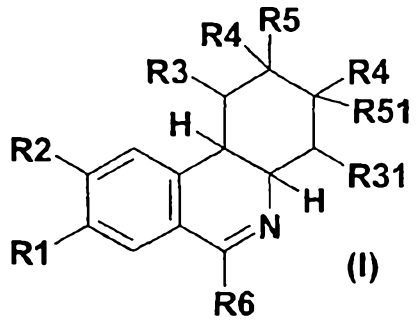
Inhibition of PDE IV activity

Compound	-log IC_{50}
1	6.09

In the claims which follow and in the preceding description of the invention, except where the context requires otherwise due to express language or necessary implication, the word "comprise" or variations such as "comprises" or "comprising" is used in an inclusive sense, i.e. to specify the presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the invention.

Patent Claims

1. N-Oxides of the compounds of formula I



in which

R1 is hydroxyl, 1-4C-alkoxy, 3-7C-cycloalkoxy, 3-7C-cycloalkylmethoxy or completely or predominantly fluorine-substituted 1-4C-alkoxy,

R2 is hydroxyl, 1-4C-alkoxy, 3-7C-cycloalkoxy, 3-7C-cycloalkylmethoxy or completely or predominantly fluorine-substituted 1-4C-alkoxy,

or in which

R1 and R2 together are a 1-2C-alkylenedioxy group,

R3 is hydrogen or 1-4C-alkyl,

R31 is hydrogen or 1-4C-alkyl,

or in which

R3 and R31 together are a 1-4C-alkylene group,

R4 is hydrogen or 1-4C-alkyl,

R5 is hydrogen,

R51 is hydrogen,

or in which

R5 and R51 together represent an additional bond,

R6 is an R7- and R8-substituted phenyl radical, where

R7 is hydroxyl, halogen, cyano, 1-4C-alkyl, 1-4C-alkoxy, 1-4C-alkylcarbonyloxy, trifluoromethyl, phenyl, phenyl-1-4C-alkyl, nitro, amino, completely or predominantly fluorine-substituted 1-4C-alkoxy, SO_2-R70 or N(R71)R72, where

R70 is 1-4C-alkyl,

R71 is hydrogen, 1-4C-alkyl, SO_2-R9 or SO_2-R10 and

R72 is 1-4C-alkyl, 1-4C-alkylcarbonyl or SO_2-R10,

R8 is hydrogen, hydroxy, halogen, 1-4C-alkoxy or 1-4C-alkyl

and where

R9 and R10 independently of one another are 1-4C-alkyl, phenyl, phenyl-1-4C-alkyl or phenyl which is substituted by one or more identical or different substituents, where the substituents are selected from the group consisting of nitro, 1-4C-alkyl, halogen, 1-4C-alkylcarbonylamino, 1-4C-alkoxy, completely or predominantly fluorine-substituted 1-4C-alkoxy, cyano, phenyl, naphthyl, trifluoromethyl or 1-4C-alkoxycarbonyl,

and the salts of these N-oxides.

2. N-oxides of the compounds of formula I according to claim 1 in which

R1 is 1-2C-alkoxy, 3-5C-cycloalkoxy, 3-5C-cycloalkylmethoxy or completely or predominantly fluorine-substituted 1-2C-alkoxy,

R2 is 1-2C-alkoxy, 3-5C-cycloalkoxy, 3-5C-cycloalkylmethoxy or completely or predominantly fluorine-substituted 1-2C-alkoxy,

R3 is hydrogen,

R31 is hydrogen,

R4 is hydrogen or 1-2C-alkyl,

R5 is hydrogen,

R51 is hydrogen,

or in which

R5 and R51 together represent an additional bond,

R6 is an R7- and R8-substituted phenyl radical, where

R7 is hydroxyl, halogen, cyano, 1-4C-alkoxy, 1-4C-alkylcarbonyloxy, trifluoromethyl, phenyl, phenyl-1-4C-alkyl, nitro, amino, completely or predominantly fluorine-substituted 1-4C-alkoxy, SO_2-R70 or N(R71)R72, where

R70 is 1-4C-alkyl,

R71 is hydrogen, 1-4C-alkyl, SO_2-R9 or SO_2-R10 and

R72 is 1-4C-alkyl, 1-4C-alkylcarbonyl or SO_2-R10,

R8 is hydrogen, halogen or 1-4C-alkoxy

and where

R9 and R10 independently of one another are 1-4C-alkyl, phenyl or phenyl substituted by a substituent, where the substituent is selected from the group consisting of nitro, 1-4C-alkyl, 1-4C-alkoxy, halogen, trifluoromethyl or 1-4C-alkoxycarbonyl,

and the salts of these N-oxides.

3. N-oxides of the compounds of formula I according to claim 1 in which

R1 is 1-2C-alkoxy,

R2 is 1-2C-alkoxy,

R3, R31, R4, R5 and R51 are hydrogen,

R6 is an R7- and R8-substituted phenyl radical, where

R7 is hydroxyl, halogen, 1-4C-alkoxy, 1-4C-alkylcarbonyloxy, phenyl, phenyl-1-4C-alkyl, nitro, amino, SO_2-R70 or N(R71)R72, where
R70 is 1-4C-alkyl,
R71 is hydrogen or SO_2-R10 and
R72 is 1-4C-alkyl, 1-4C-alkylcarbonyl or SO_2-R10,

R8 is hydrogen, halogen or 1-4C-alkoxy

and where

R10 is phenyl substituted by a substituent, where the substituent is selected from the group consisting of nitro, 1-4C-alkyl or 1-4C-alkoxycarbonyl,

and the salts of these N-oxides.

4. N-oxides of the compounds of formula I according to claim 1 in which

R1 is 1-2C-alkoxy,

R2 is 1-2C-alkoxy,

R3, R31, R4, R5 and R51 are hydrogen,

R6 is an R7- and R8-substituted phenyl radical, where

R7 is SO_2-R70,
R60 is 1-4C-alkyl,

R8 is hydrogen,

and the salts of these N-oxides.

5. N-oxides of the compounds of formula I according to any one of the claims 1, 2, 3 or 4, which in the positions 4a and 10b have the same absolute configuration as the compound (-)-cis-1,2-dimethoxy-4-(2-aminocyclohexyl)benzene which on its part can be employed as a starting material having the optical rotation $[\alpha]_D^{20}$ =-58.5° (c=1, ethanol).

6. N-oxides of the compounds of formula I according to any one of claims 1 to 5 for the treatment of diseases.

7. A medicament comprising one or more N-oxides of the compounds of formula I according to any one of claims 1 to 5 together with customary pharmaceutical auxiliaries and/or excipients.

8. Use of N-oxides of the compounds of formula I according to any one of claims 1 to 5 for the production of medicaments for the treatment of airway disorders.

9. Use of N-oxides of the compounds of formula I according to any one of claims 1 to 5 for the production of medicaments for the inhibition of PDE.

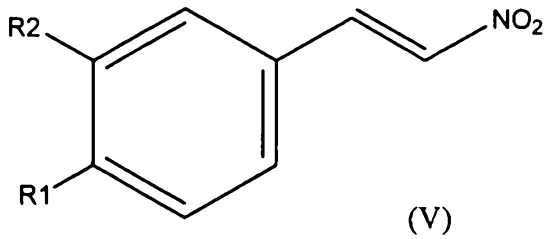
10. A method for the treatment and/or prophylaxis of airway disorders, comprising administering a therapeutically effective amount of an N-oxide of the compounds of formula I as defined in any one of claims 1 to 5 to a subject in need thereof.

11. A method for inhibiting PDE, comprising administering a therapeutically effective amount of an N-oxide of the compounds of formula I as defined in any one of claims 1 to 5 to a subject in need thereof.

12. Use of N-oxides of the compounds of formula I as defined in any one of claims 1 to 5 as a PDE inhibitor.

13. Use of N-oxides of the compounds of formula I as defined in any one of claims 1 to 5 in the treatment of airway disorders.

14. A process for preparing N-oxides of the compounds of formula I as defined in any one of claims 1 to 4, comprising the step of:
reacting a compound of formula (V)



(V)

in which:
R1 and R2 are as defined in claim 1
with a compound of formula (VI)

R3-CH=C(R4)-C(R4)=CH-R31 (VI)

in which
R3, R4 and R31 are as defined in claim 1.

15. N-oxides, medicaments comprising them, methods or uses involving them, or processes for their preparation, substantially as herein described with reference to the accompanying examples.

Dated this 6th day of June 2005
ALTANA PHARMA AG
By their Patent Attorneys
GRIFFITH HACK
Fellows Institute of Patent and
Trade Mark Attorneys of Australia